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TECHNICAL REPORT 2605

AD 304740

EVALUATION OF COMPOSITION B AND CYCLOTOL IN THE 4.2-INCH M329 HE MORTAR SHELL (U)

ROBERT J. HEREDIA
MARTIN J. MARGOLIN

APRIL 1959

FELTMAN RESEARCH AND ENGINEERING LABORATORIES
PICATINNY ARSENAL
DOVER, N. J.

ORDNANCE PROJECT TW-112

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DESCRIPTORS: *EXPLOSIVES, *FRAGMENTATION, EFFECTIVENESS, HIGH EXPLOSIVE AMMUNITION, MORTAR AMMUNITION, PROJECTILES, TESTS (U)

IDENTIFIERS: M-329 CARTRIDGES(4.2-IN.) (U)

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EVALUATION OF COMPOSITION B AND CYCLOTOL IN THE 4.2-INCH M329 HE MORTAR SHELL (U)

by

Robert J. Heredia
Martin J. Margolin

April 1959

Feltman Research and Engineering Laboratories
Picatinny Arsenal
Dover, N.J.

Technical Report 2605

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Dept of the Army Project 5A04-03-053

Approved:

L. H. ERIKSEN
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Propellants Laboratory

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(U) OBJECT

To investigate the suitability of Composition B and cyclotol for use as bursting charges for 4.2-inch M329 HE mortar shell.

(C) SUMMARY

In an attempt to improve the fragmentation efficiency of the 4.2-inch M329 HE shell, Picatinny Arsenal investigated the use of Composition B and cyclotol as bursting charges for this shell.

M329 shell loaded with Composition B and cyclotol were subjected to panel recovery tests. In these tests, cyclotol-loaded shell produced average fragment velocities (nose, side, and tail) of 1920, 6430, and 4757 fps, and Composition B-loaded shell produced velocities of 1870, 6072, and 4657 fps.

In similar tests, TNT-loaded shell showed average fragment velocities of 1749, 5238, and 2203 fps. The average total number of recovered fragments was 854 and 876 for cyclotol and Composition B-loaded shell, compared to 519 for TNT-loaded shell. Spatial distribution of fragments was about the same for all three explosives.

Lethal areas were calculated for various burst heights on the basis of the following assumptions: side spray only considered, terminal velocity 450 fps, angle of fall of shell 55°, prone men as targets, and the 5-minute assault criterion. For burst heights ranging from 0 to 50 feet, the average increase in lethal area over TNT was 24% for cyclotol and 20% for Composition B.

(U) CONCLUSION

Composition B and cyclotol show no significant differences in performance in the 4.2-inch M329 HE mortar shell, but both are more effective than TNT.

(U) RECOMMENDATION

Composition B should be adopted as the standard filler for the 4.2-inch M329 HE mortar shell, in the event of a production requirement for this shell.

(U) INTRODUCTION

1. At the request of Office, Chief of Ordnance (Ref 1), Picatinny Arsenal undertook an investigation into the suitability of Composition B as the standard filler for the 76 mm M42A1 HE shell. This investigation culminated in the standardization of Composition B for use in this shell (Ref 2). Reference 3 recommended a continuation of the Composition B loading investigation to include all present standard HE shell. Since the initiation of this investigation, work has been completed resulting in the standardization of Composition B in the 90 mm M71 and 105 mm M1 HE shell (Refs 3 and 4).

2. During the evaluation of Composition B as a replacement for TNT in HE shell, Picatinny Arsenal recommended to Office, Chief of Ordnance that explosives of greater brisance than Composition B also be investigated. The cyclotols and the octols, which have an inherent capability of increasing the lethality of HE shell, were suggested. Use of cyclotol (70/30 and 75/25) was investigated for the 90 mm M71 and the 105 mm M1 HE shell. The results showed these explosives to be superior to Composition B (Ref 5). Similarly, separate investigations of the use of cyclotol in the 60 mm M49A2 and the 57 mm M306A1 HE shell have shown cyclotol to produce a more lethal shell (Refs 6 and 7).

3. OCM Item 36017 (Ref 8) established a precedence list for the utilization of Composition B in fragmentation ammunition. High on this list (Group I, Item Number 2) was the 4.2-inch mortar shell. Accordingly, Picatinny Arsenal initiated an investigation of the replacement of TNT with Composition B in the M329 shell. Cyclotol was also investigated as a possible bursting charge for this shell, on the basis of the results reported in References 5, 6, and 7.

4. To evaluate Composition B and cyclotol for this shell with a minimum of expenditure, it was decided to use, for TNT, data from an earlier investigation (Ref 9) in which panel recovery tests of M329 shell loaded with TNT and with Composition B had been conducted. This data was to be correlated with the results of similar tests (Ref 10) of shell loaded with Composition B and with cyclotol.

(C) RESULTS

5. The results of fragment velocity tests of 15 M329 mortar shell, 5 loaded with Composition B, 5 with cyclotol, and 5 with TNT are summarized in Tables 2, 3, and 4 (pp 7, 8, and 9). Average side spray fragment velocities at 20.5 feet and average nose and tail spray velocities at 15 feet may be summarized as follows:

	Avg Fragment Velocity, fps
Side	
Cyclotol	6430
Comp B	6072
TNT	5234
Nose	
Cyclotol	1920
Comp B	1870
TNT	1749
Tail	
Cyclotol	4757
Comp B	4657
TNT	2203

6. Table 5 (p 10) gives the fragment distribution results for cyclotol-, Composition B-, and TNT-loaded M329 shell. The average total number of fragments recovered was 876 for Composition B, 854 for cyclotol, and 519 for TNT. The number of larger fragments (50 grains or more) was about the same for all types of loading but

Composition B and cyclotol produced 838 and 815 recovered fragments in the 0 to 50-grain fragment sizes, while TNT produced only 478.

7. Lethal areas were calculated on the basis of the data presented in Tables 2 through 5 (pp 7 through 10). The target was assumed to be prone men on the surface of the ground. Terminal projectile velocity and angle of fall were assumed to be 450 fps and 55°. Only shell fragments from the side spray (static, between 78° to 102°) were considered and all lethality calculations were based on the 5-minute assault criterion. The results, shown graphically in Figure 2 (p 12), are also presented in Table 1 below.

(C) DISCUSSION OF RESULTS

8. Analysis of the fragment velocity data contained in Tables 2, 3, and 4 (pp 7, 8, and 9) shows that M329 shell loaded with cyclotol and Composition B produced greater fragment velocities than TNT-loaded M329 shell. The increases in velocity were side spray, 22% and 16%, nose spray, 10% and 7%, and tail spray, 116% and 111%. These results agree with the mass distribution data in Table 5 (p 10), which also shows Composition B and cyclotol to be considerably more effective than cast TNT.

9. Analysis of the fragment weight distribution data given in Table 5 shows

TABLE 1

Lethal Areas (in sq ft) for Various Burst Heights

Burst Height, ft	Cyclotol	Composition B	TNT
0	2450	2380	1930
5	4600	4430	3810
10	5180	5000	4280
15	5550	5380	4520
20	5850	5710	4660
22.5	6070	5870	4940
25	6480	6180	5150
27.5	6150	5910	4870
30	5980	5730	4710
35	5330	5210	4250
40	4840	4590	3810
50	3940	3790	3200

that shell loaded with Composition B or cyclotol produced larger numbers of fragments (876 and 854, respectively) than shell loaded with TNT (519 fragments). This difference is in the 0 to 50-grain group. In this weight group, Composition B and cyclotol exceeded TNT by about 80% and 75% in the average number of recovered fragments per shell. Relatively few fragments weighing more than 50 grains were produced and these were about equally numerous for all three types of shell loading. A possible explanation of the fact that a larger number of fragments were recovered from the Composition B-loaded shell than from the cyclotol-loaded shell may be found by examining the average fragment weight columns of Table 5 (p 10). These columns show that, in the 0 to 25-grain group, which is the group in which Composition B achieves most of its advantage over cyclotol in number of fragments, the average fragment weight is 3.53 grains for Composition B but only 3.31 grains for cyclotol. This leads to the belief that, in the thin-walled M329 shell, cyclotol has sufficiently greater "dusting" losses to account for the difference between cyclotol and Composition B in number of recovered fragments.

10. The fragment spatial distribution results for Composition B, cyclotol, and TNT were evaluated in terms of hits per unit solid angle and were plotted for 180° coverage (nose to tail). The curves obtained for Composition B and cyclotol almost coincide (Fig 1, p 11). Thus, both in total number of fragments and in spatial distribution of fragments, the Composition B-loaded shell and the cyclotol-loaded shell show approximately equal fragmentation efficiency. The TNT-loaded shell produced a smaller number of hits per unit solid angle (nose to tail) than either the Composition B- or the cyclotol-loaded shell. These results, which are in agreement with the fragment velocity results, indicate that both Composition B- and cyclotol-loaded M329 shell are much more effective than TNT-loaded M329 shell, and that there is little, if any, difference between cyclotol and Composition B for this round.

11. This conclusion is borne out by the results of the lethal area computations. At the optimum burst height (25 ft), cyclotol and Composition B are, respectively, 26% and 20% more effective than TNT. Over the range of burst heights considered, the average increase in effectiveness over TNT is 24% for cyclotol and 20% for Composition B.

12. The data presented for cyclotol- and Composition B-loaded shell in this report was obtained from recent tests. The TNT data is corrected data obtained from an earlier test of TNT versus Composition B. In order to allow direct comparison of this data, the mass and spatial distribution values for TNT were correlated with those presented for cyclotol and Composition B by a correction factor. The factor used was the ratio of the corresponding values obtained for Composition B in each test, assuming that the relationship between

Composition B and TNT results was constant over the different test conditions.

13. Any additional cost incurred by loading the M329 shell with either Composition B or cyclotol instead of TNT is insignificant in the light of the increases in number of fragments produced and in fragment velocities that can be obtained with these two explosives. The estimated costs, \$.60 per lb for cyclotol and \$.43 per lb for Composition B, would mean an increase over the cost of TNT-loaded shell of from \$.13 to \$.18 per shell. Full-scale production would reduce these extra costs by about one-half. No difficulty is anticipated in loading either Composition B or cyclotol. Present facilities and equipment for loading TNT into the M329 shell could be used.

14. Composition B is less expensive than cyclotol, it contains less RDX (which might be critically needed in any future emergency), and it is equal to cyclotol in effectiveness as the M329 bursting charge. Hence, it is considered that Composition B, in preference to cyclotol, should be adopted as the standard filler in the event of any production requirement for this shell.

(U) EXPERIMENTAL PROCEDURE

15. The shell used in the tests discussed in this report were loaded as follows:

a. Five with cast Grade A Composition B (Spec PA-PD-24, Rev 1, 13 August 1953) in two pours at $86^\circ \pm 1^\circ$C. A funnel (SO-1158D) was used during the second pour and the shell were filled to within one-half inch of the top of the funnel. The fuze cavity was drilled to the dimensions shown in Figure 2 (p 12).

b. Five with cast cyclotol (Spec PA-PD-222, Rev 1, 31 July 1953) according to procedure outlined in paragraph 15a except that the pouring temperature was $91^\circ \pm 1^\circ$C for the first increment and $95^\circ \pm 1^\circ$C for the second increment.

c. No loading description is available for the shell loaded with TNT for the tests described in Reference 9, other than that these shell were cast-loaded and were from Lot LS-1-2.

16. All cyclotol- and Composition B-loaded shell were assembled with M54 fuzes (Fig 3, p 13) modified for static firing. Supplementary charges (Lot IOP 1-22) were assembled to all shell.

17. In the fragment distribution and velocity tests, the shell were suspended individually 4 feet above ground level in a horizontal position within a semicircle of recovery boxes. The radius of the semicircle (from the suspended shell to the row of recovery boxes) was approximately 21 feet. The recovery boxes, which were 4 feet wide, 8 feet high, and 3 feet deep, were numbered 1 to 15, going from the box closest to the nose section of the shell to the box nearest its tail section. To provide the basis for a more accurate determination of the spatial distribution of the fragments,

each box was divided into sections designated A and B. All the boxes were filled with sheets of composition wall-board, 96 inches high by 48 inches wide by ½ inch thick. Fragment velocities were determined photographically by means of 4 high-speed movie cameras operating at approximately 8000 frames per second. The velocity targets were 4-foot-wide by 8-foot-high by .020-inch-thick dural sheets, placed in a vertical position to cover an arc of 180 degrees. Flash bulbs were placed in certain targets to make possible the determination of fragment velocities of 1700 fps and under. This test is described in Reference 10.

18. The test procedure for the TNT-loaded shell (described in Reference 9) was similar to that described in paragraph 17 above. The shell were suspended individually 4 feet above ground level within a semicircle of recovery boxes. The radius of the semicircle (from the suspended shell to the row of recovery boxes) was approximately 25.24 feet. The dimensions and filler of the recovery boxes were identical to those described in paragraph 17. A total of 3 velocity and 18 recovery boxes were used. Fragment velocities were determined by the method described in paragraph 17.

19. Lethal areas were calculated from panel recovery test results taken from Reference 10. The shell was assumed to have burst at various heights, with a 55° angle of fall, a terminal velocity of 450 fps, prone men as targets, and the 5-minute assault criterion.

(U) ACKNOWLEDGMENT

The valuable assistance of Mr. L. Nichols of the Ammunition Research Laboratory in conducting the lethality analysis is acknowledged.

(C) REFERENCES

1. Ltr., dtd 3 July 1947, O.O 400.112/11763; ORDBB 400.112/752-94
2. OCM Item 33201 dtd 16 March 1950
3. OCM Item 34042 dtd 17 January 1952
4. OCM Item 34125 dtd 13 March 1952
5. L. Jablansky, *Evaluation of 70/30 Cyclotol and 75/25 Cyclotol for Use in HE and HEAT Projectiles,* Picatinny Arsenal Technical Report 1944, August 1953
6. M.J. Margolin and C.D. Hartman, *Investigation of Composition B and Cyclotol for Use in 60 mm M49A2 HE Shell (C),* Picatinny Arsenal Technical Report 2360, September 1956
7. R.J. Heredia, *Evaluation of Composition B and Cyclotol for Use in 57 mm M306A1 HE Shell (U),* Picatinny Arsenal Technical Report 2446, August 1957
8. OCM Item 36017 dtd 1 December 1955
9. Aberdeen Proving Ground Firing Record B-10,001A, 3 January to 3 May 1952
10. Aberdeen Proving Ground Firing Record B-14100, November 1956 to April 1957

TABLE 2

Fragment Velocity Results[a] of Panel Recovery Tests of Cyclotol-Looded 4.2-Inch M329 Shell

Shell No.	No. of Fragments Recovered[b]	Average Fragment Weight, grains	No. of Velocities Recorded[c]	Average Velocity, fps
		SIDE SPRAY (78° to 102°, Boxes 7B through 9A)		
11	211	13.92	72	6573 (6400)[d]
10	273	10.37	70	6453
8	184	14.71	72	6417
9	372	9.59	67	6415
7	335	8.22	51	6477
Average	275	10.76	66.4	6430[e]
		NOSE SPRAY (0° to 12°, Boxes 1A and 1B)		
11	100	7.4	1	2547
10	59	28.1	19	1890
8	62	11.1	28	1767
9	63	22.5	22	1949
7	45	47.5	26	2149
Average	66	19.6	19	1920
		TAIL SPRAY (168° to 180°, Boxes 15A and 15B)		
11	294	8.5	12	4776
10	197	14.1	52	4844
8	193	14.6	39	4807
9	369	5.9	54	4959
7	335	7.2	24	4401
Average	278	9.1	36	4757

[a] Velocity results taken from APG Firing Record B-14100

[b] Fragments recovered from recovery boxes, distance 21 feet

[c] Side spray velocities measured over a distance of 20.5 feet, except Shell No. 11 for which a distance of 15 feet was used; nose and tail spray velocities measured over a distance of 15 feet

[d] Corrected to 20.5 feet

[e] Corrected average

TABLE 3

Fragment Velocity Results[a] of Panel Recovery Tests of Composition B-Loaded 4.2-Inch M329 Shell

Shell No.	No. of Fragments Recovered[b]	Average Fragment Weight, grains	No. of Velocities Recorded[c]	Average Velocity, fps
		SIDE SPRAY (78° to 102°, Boxes 7B through 9A)		
5	370	8.79	61	5945 (5749)[d]
2	285	10.12	75	6135
1	284	11.12	41	6180
3	368	8.95	56	5935
4	349	9.05	76	6362
Average	331	9.5	62	6072[e]
		NOSE SPRAY (0° to 12°, Boxes 1A and 1B)		
5	67	20.25	–	–
2	51	76.85	6	1844
1	29	42.36	12	2003
3	60	46.41	12	1913
4	72	14.33	13	1681
Average	56	36.99	11	1870
		TAIL SPRAY (168° to 180°, Boxes 15A and 15B)		
5	190	12.17	3	5209
2	300	8.69	50	4537
1	286	7.47	45	4224
3	212	8.25	29	4916
4	282	8.80	24	4401
Average	254	8.89	30	4657

[a] Velocity results taken from APG Firing Record B-14100

[b] Fragments recovered from recovery boxes, distance 21 feet

[c] Side spray velocities measured over a distance of 20.5 feet, except Shell No. 5 for which a distance of 15 feet was used; nose and tail spray velocities measured over a distance of 15 feet

[d] Corrected to 20.5 feet

[e] Corrected average

TABLE 4

Fragment Velocity Results[a] of Panel Recovery Tests of TNT-Loaded 4.2-Inch M329 Shell

Shell No.	No. of Fragments Recovered	Average Fragment Weight, grains	Average Velocity, fps[b]
		SIDE SPRAY	
11	71	30	5137
12	122	22	4927
13	99	29	5062
14	93	22	4955
15	67	29	5002
Average	90	26	5017 (5238)[c]
		NOSE SPRAY	
11	–	–	–
12	7	483	1543
13	4	41	1890
14	–	–	–
15	–	–	–
Average	5.5	331	1712 (1749)[d]
		TAIL SPRAY	
11	–	–	–
12	–	–	–
13	31	–	–
14	31	37	2126
15	33	61	2120
Average	32	49	2123 (2203)[d]

[a] Velocity results taken from APG Firing Record B-10,001A

[b] Velocities presented for individual shell average over 25 feet

[c] Corrected to 20.5 feet

[d] Corrected to 15 feet

TABLE 5

Mass Fragment Distribution Results[a] of Panel Recovery Tests of 4.2-Inch M329 Shell

Fragment Size, grains	5 Rounds Cyclotol		5 Rounds Composition B		5 Rounds TNT[b]	
	Avg. No. of Fragments	Avg. Wt. per Fragment, gr	Avg. No. of Fragments	Avg. Wt. per Fragment, gr	Avg. No. of Fragments	Avg. Wt. per Fragment, gr
0 - 25	767.6	3.31	785.2	3.53	440.3	3.92
25 - 50	47.8	35.86	53.2	34.44	37.8	36.08
50 - 75	17.4	59.56	17.6	71.56	18.1	71.34
75 - 150	13.6	102.44	12.6	94.56	13.4	88.22
150 - 750	5.4	244.81	5.4	281.22	7.5	283.93
750 - 2500	1.8	1332.89	2.4	1239.17	2.1	1382.53
Over 2500	0.0	0.0	0.0	0.0	0.0	0.0
Totals	853.6		876.4		519.2	

[a] Distribution results taken from APG Firing Record B-14100

[b] Data presented herein for TNT rounds corrected as discussed in paragraph 10

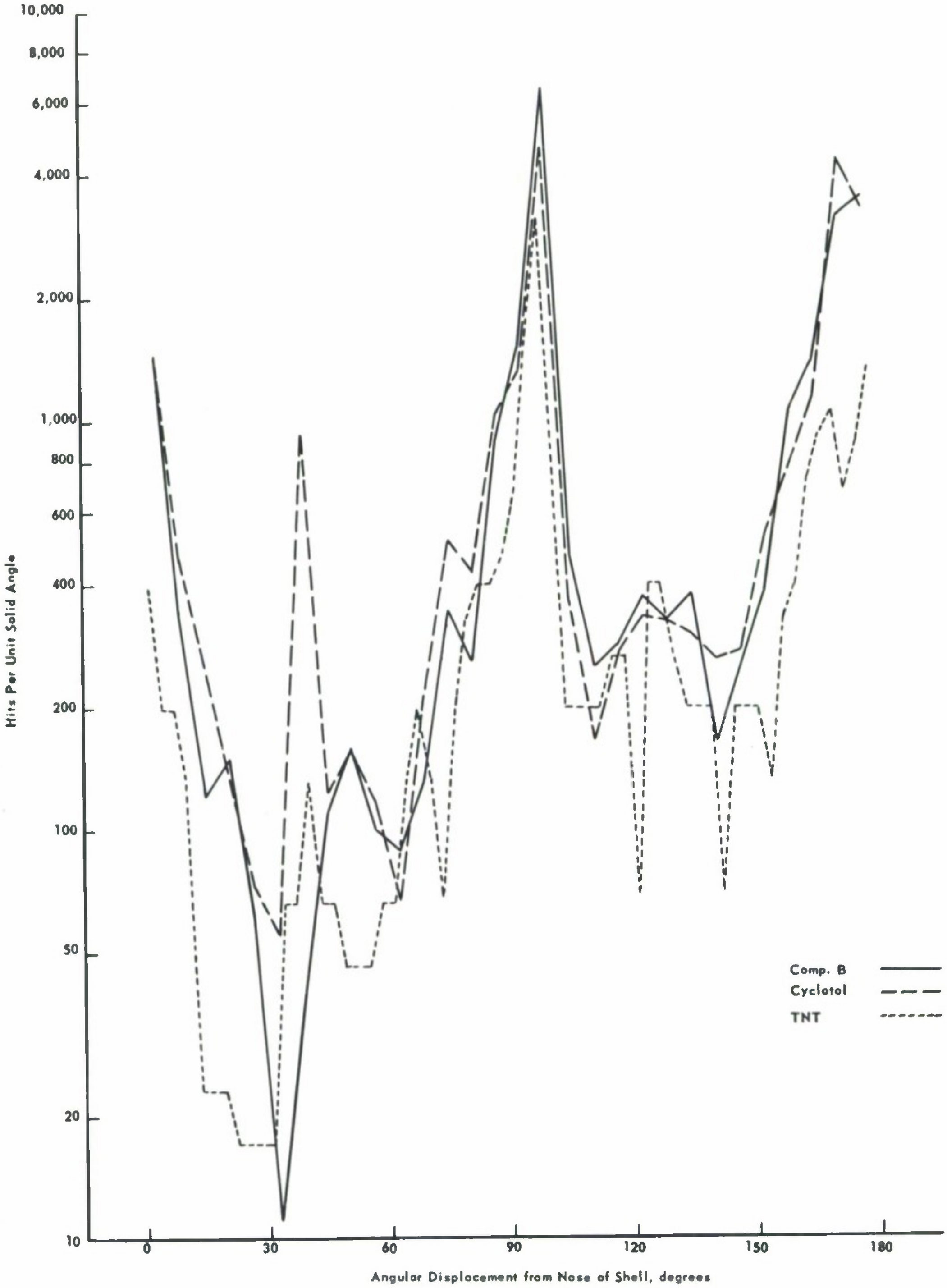

Fig 1 Number of Hits Per Unit Solid Angle at Each Panel

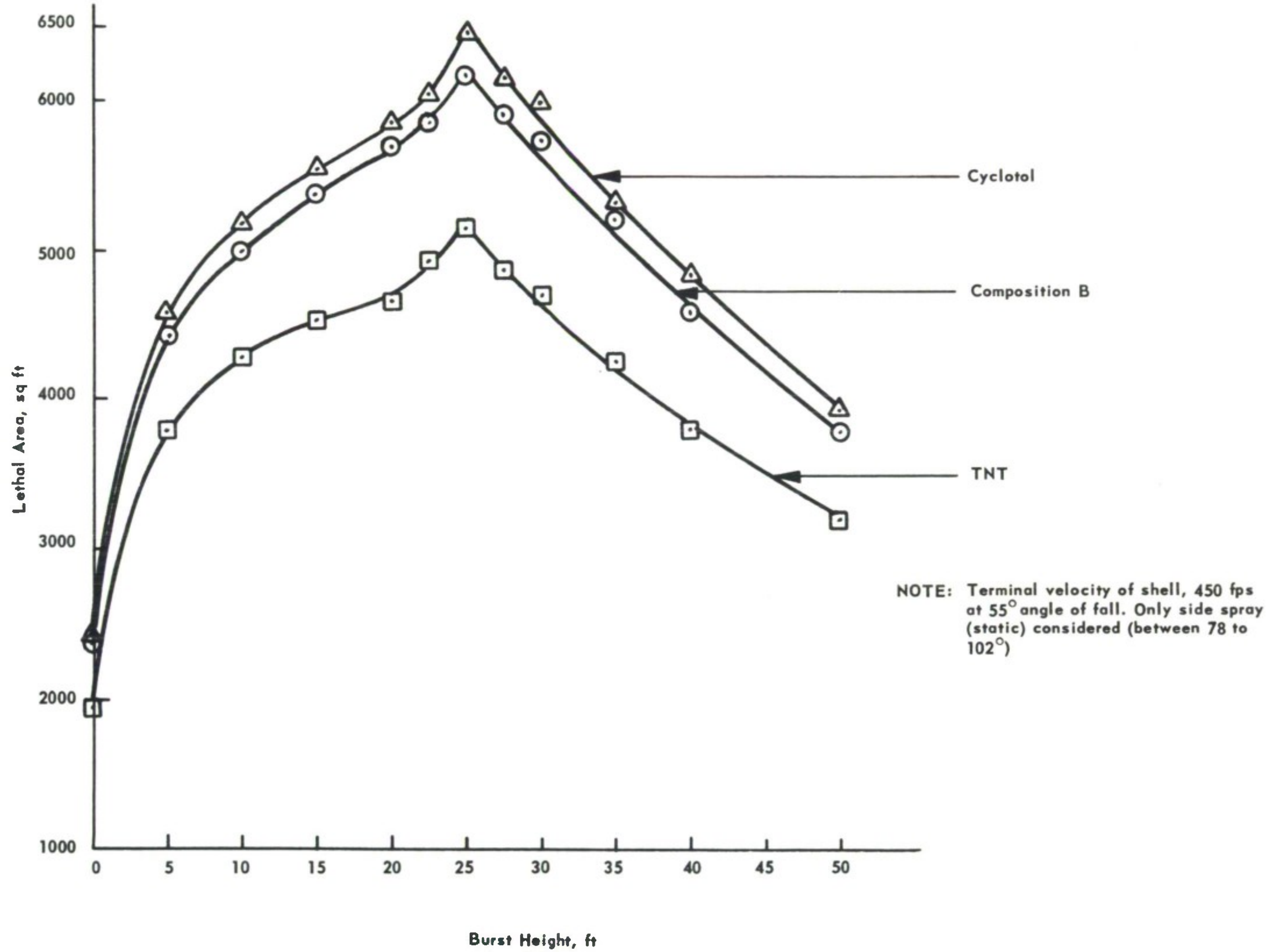

Fig 2 Lethal Area vs Burst Height for 4.2-Inch M329 Shell (Against prone men using 5-minute assault criterion)

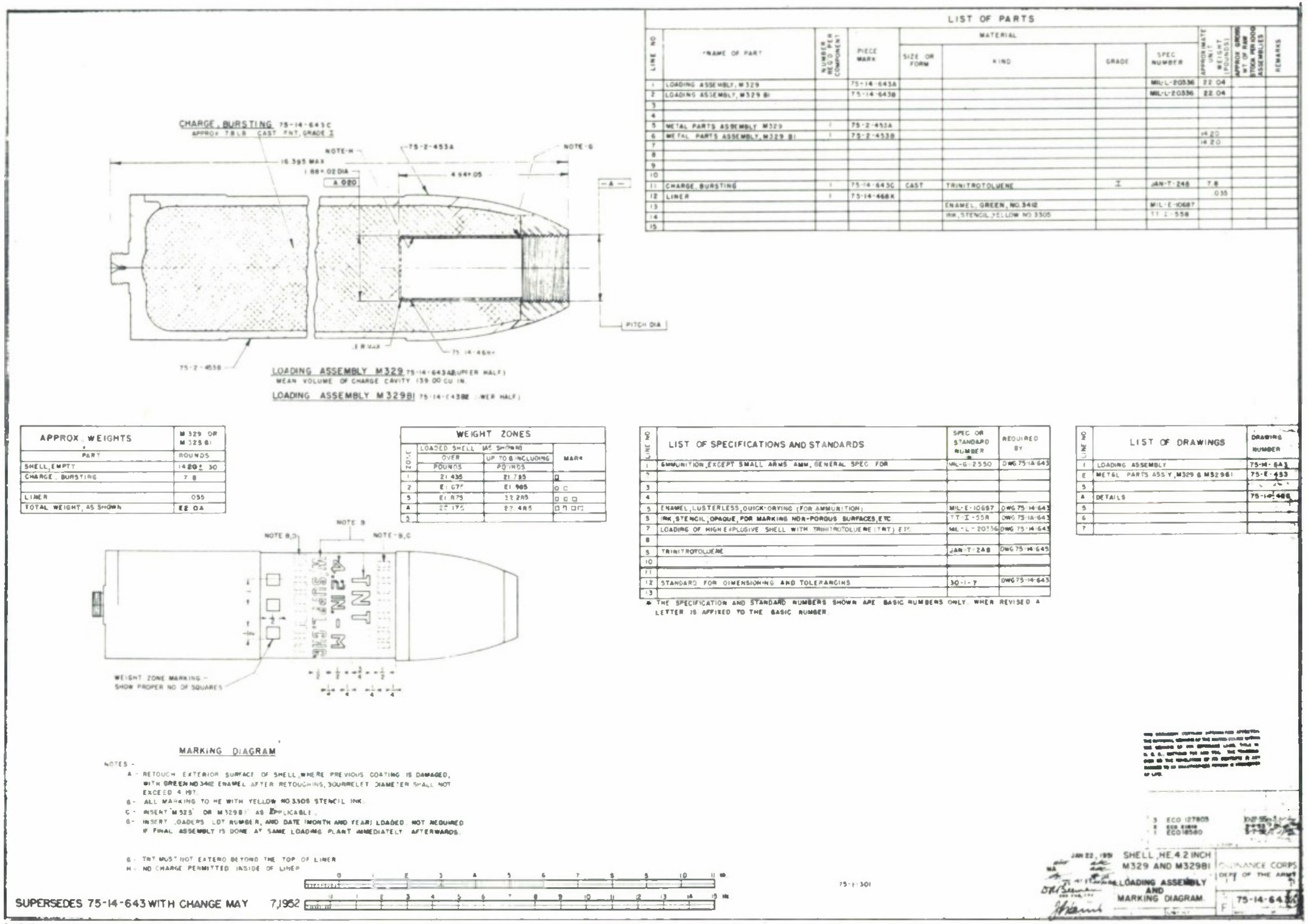

Fig 3 Loading Assembly for 4.2-Inch M329 HE Shell

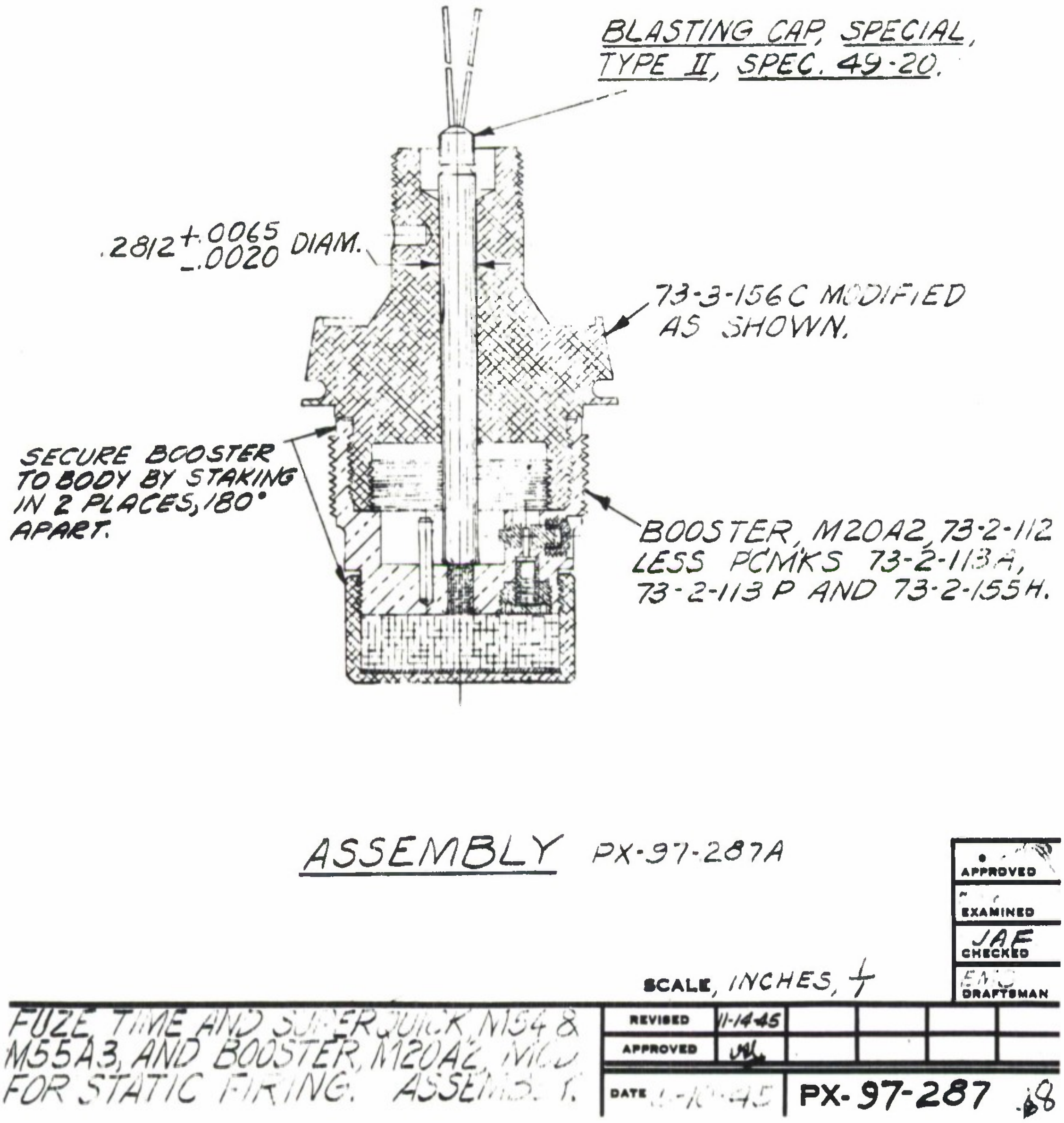

Fig 4 M54 and M55A3 Time and Superquick Fuzes and M20A2 Booster Modified for Static Firing

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CORRECTION SHEET

Feltman Research and Engineering Laboratories
Picatinny Arsenal
Dover, N. J.

C-9258

REPORT NUMBER 2605
REPORT DATE April 1959
AUTHOR Robert J. Heredia, Martin J. Margolin
TITLE Evaluation of Composition B and Cyclotol in the 4.2-Inch M329 HE Mortar Shell (U)

Please correct the Picatinny Arsenal report identified above as shown below:

Page	Par.	Correction
1	5	Change the last sentence in the Summary to read: For burst heights ranging from 10 to 30 feet, the average increase in lethal area over TNT was 23% for cyclotol and 19% for Composition B.
3		Replace Table 1 with the revised Table 1 attached.
4	11	Paragraph 11 should read as follows: This conclusion is borne out by the results of the lethal area computations. At the optimum burst height (22.5 ft) cyclotol and Composition B are, respectively, 23% and 19% more effective than TNT. These are also the average increases in effectiveness of the cyclotol and Composition B.
12		Replace Figure 2 with the revised Figure 2 attached.

Regraded unclassified when separated from Figure 2

AID-1158-59

Correction Date 6 August 1959

[redacted]AL

TABLE 1

Lethal Areas (in sq ft) for Various Burst Heights

Burst Height, ft	Cyclotol	Composition B	TNT
10	5520	5320	4580
15	5870	5660	4850
20	6080	5880	4970
22.5	6110	5900	4960
25	6090	5890	4920
27.5	6050	5870	4860
30	5960	5800	4760

Regraded unclassified when separated from Figure 2

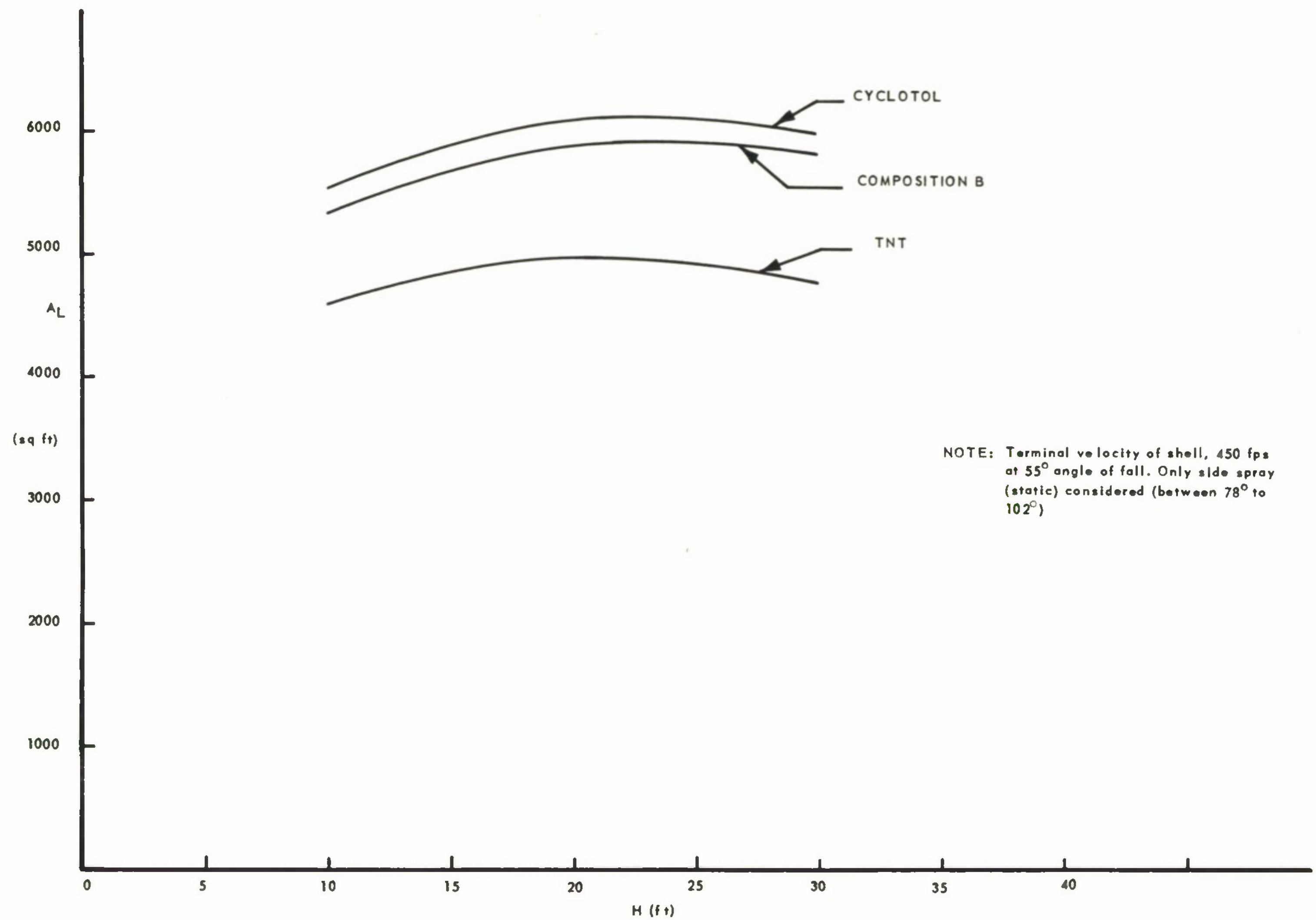

Fig 2 Lethal Area (A_L) vs Burst Height (H) for 4.2-Inch M329 Shell (Against prone men using 5-minute assault criterion)